

PREVALENCE OF *PARAGONIMUS* INFECTION IN CRAB HOSTS IN TAIWAN¹

JUI-KUANG CHIU²

Received for publication August 20, 1964

ABSTRACT

A total of 10,763 crabs, belonging to 18 species, collected from different areas in Taiwan were examined for *Paragonimus*. The presence of the rodent lung fluke, *P. iloktsuenensis*, was recorded for the first time. This parasite is restricted in distribution to Alilao village of Taipei County. *P. westermani* was found distributed in north-western Taiwan, particularly in Taipei, Hsinchu and Miaoli Counties. The prevalence of infections in the crab hosts are given in TABLE I. It was observed that the occurrence of *Paragonimus* infection in the crab, *Potamon Rathbuni*, has decreased in the last twenty years in Taoyuan, Hsinchu and Miaoli Counties. In contrast, no decrease was found in the crab, *Eriocheir japonicus*, during the last two decades.

Four species of crab-transmitted trematodes other than *Paragonimus* were found in the present study. Of these, one was a new species and two were recorded for the first time in Taiwan.

Nearly twenty species of *Paragonimus* in Asia, Africa and the Western Hemisphere have been described since the discovery of *Paragonimus rufus* by Diesing in 1850 (1). Of these, only *Paragonimus westermani* is known in Taiwan recently. Kinugasa (2) and Sai (3) made extensive county wide surveys for *P. westermani* infections in *Eriocheir* and *Potamon* crabs in Taoyuan, Hsinchu, and Miaoli Counties, and Taichung, Changhua and Nantou Counties, respectively. Huang and Chiu (4) determined the rate of *P. westermani* infection in *Eriocheir japonicus* crabs being marketed in Taipei city for the purpose of the investigation of the increase in the number of paragonimiasis patients in this city after the war. During a skin test study

with purified derivatives of *P. westermani* and *Clonorchis sinensis* in inhabitants in Hsinchu County, Watten, Kuntz and Liu (5) also examined a considerable number of *Eriocheir* and *Potamon* crabs.

Since 1959 extensive examinations of crabs have been made by the author in order to secure more information about the genus *Paragonimus* on this island. Consequently, the presence of *Paragonimus iloktsuenensis* was recorded (6). The present paper is to record those findings obtained from the crab examinations. Some previous published data are included in this report for the sake of completeness.

MATERIALS AND METHODS

A total of 10,763 crabs were collected from various areas in Taiwan, mostly from August 1959 to February 1962 and a few in 1964. The majority of crabs were obtained from the plain area of the

1 This study was supported by a research grant from the National Council on Science Development of the Republic of China.

2 Associate Professor, Department of Parasitology, College of Medicine, National Taiwan University, Taipei, Taiwan.

island. Special attention was given to brackish water crabs because they host rodent *Paragonimus* in China mainland and Japan. Crabs examined comprised 9 genera and 18 species, i.e., *Eriocheir japonicus* de Haan, *Eriocheir rectus* Stimpson, *Potamon Rathbuni* de Man, *Potamon dehaani* (White), *Potamon formosanus* Parisi, *Potamon (Geothelphusa)* sp. *, *Parathelphusa sinensis* H. M. Edwards, *Sesarma dehaani* H. M. Edwards, *Sesarma bidens* (de Haan), *Sesarma plicatum* (Latreille), *Sesarma haematocheir* (de Haan), *Sesarma impressa* H. M. Edwards, *Helice tridens tridens* (de Haan), *Helice tridens wuana* Rathbuni, *Chasmagnathus convexus* de Haan, *Varuna litterata* (Fabricius), *Goetice depressa* (de Haan), and *Hemigrapsus penicillatus* (de Haan).

To examine the crabs, the gills, liver and other internal organs were removed, compressed between two large slides and examined under a dissecting scope. Muscles were examined only in *Eriocheir*, *Potamon* and *Parathelphusa* crabs. The cephalothorax, without carapace, and the legs were minced with a meat grinder, washed through a metal sieve with water, and allowed to settle. The sediment was examined with a dissecting scope. The muscles of *Potamon* sp. from the endemic area of *Paragonimus iloktsuenensis*, Alilao village of Taipei County, were dissected from the exoskeleton and examined by press preparation. Only the gills were examined in some *Eriocheir* crabs that were 41 mm or more in breadth of carapace.

RESULTS AND DISCUSSION

The metacercariae of *P. westermani* were found in four species of the fresh water crabs, i.e., *E. japonicus*, *P. Rathbuni*, *P. dehaani* and *Potamon* sp.. This conventional type of lung fluke was found widely distributed in north-western Taiwan (Fig. 1). Infection rates varied from 1.3

to 89.6% according to the species of the crab host and locality (TABLE I). *E. japonicus* is considered to be the most important vector in transmission of human paragonimiasis in plain area. The highest infection occurred in this species of crab from Taipei County (29.6% or 4.78 of cysts per crab examined), whereas in Hsinchu and Miaoli Counties almost the same degree of infections were obtained (5.1% or 0.08 of cyst per crab for the former and 7.1% or 0.19 for the latter). The lowest infection was observed in Taoyuan County (0.4% or 0.004 of cyst per crab). The crab host, *P. Rathbuni*, is more important in acting as a source of human infection in the mountainous area. Hsinchu and Miaoli Counties again showed the same degree of infections in this species of crab, i.e., 12.3% or 0.28 of cyst per crab examined for the former and 13.5% or 0.47 for the latter. Only two crabs were found infected with *Paragonimus* metacercariae in Taoyuan County.

Comparing the intensity of infection of the present study with that reported by Kinugasa (2) in Taoyuan, Hsinchu and Miaoli Counties, there has been a decreasing prevalence of infection in *P. Rathbuni* during the last twenty years (TABLE II). An average number of metacercariae per crab examined was more than 1 in 1943, while it was less than 1 in the present study. In general, no decrease was observed in *E. japonicus* from Taoyuan and Hsinchu Counties, while in Miaoli County there is a little decrease of infection (0.66 to 0.19 of cyst per crab). Sai (3) collected 316 *Paragonimus* metacercariae from 1,470 *P. Rathbuni* with an average number of cyst per crab of 0.2, and 78 cysts from 965 *E. japonicus* with an average number of cyst per crab of 0.08 in Taichung, Changhua and Nantou Counties. However, no positive crabs were detected from those counties in the present study.

Infected *P. dehaani* crabs were found

* Regarding the identification of this crab, refer to the paper published by the author in the *Journal of Parasitology*, 48: 423. (1962).

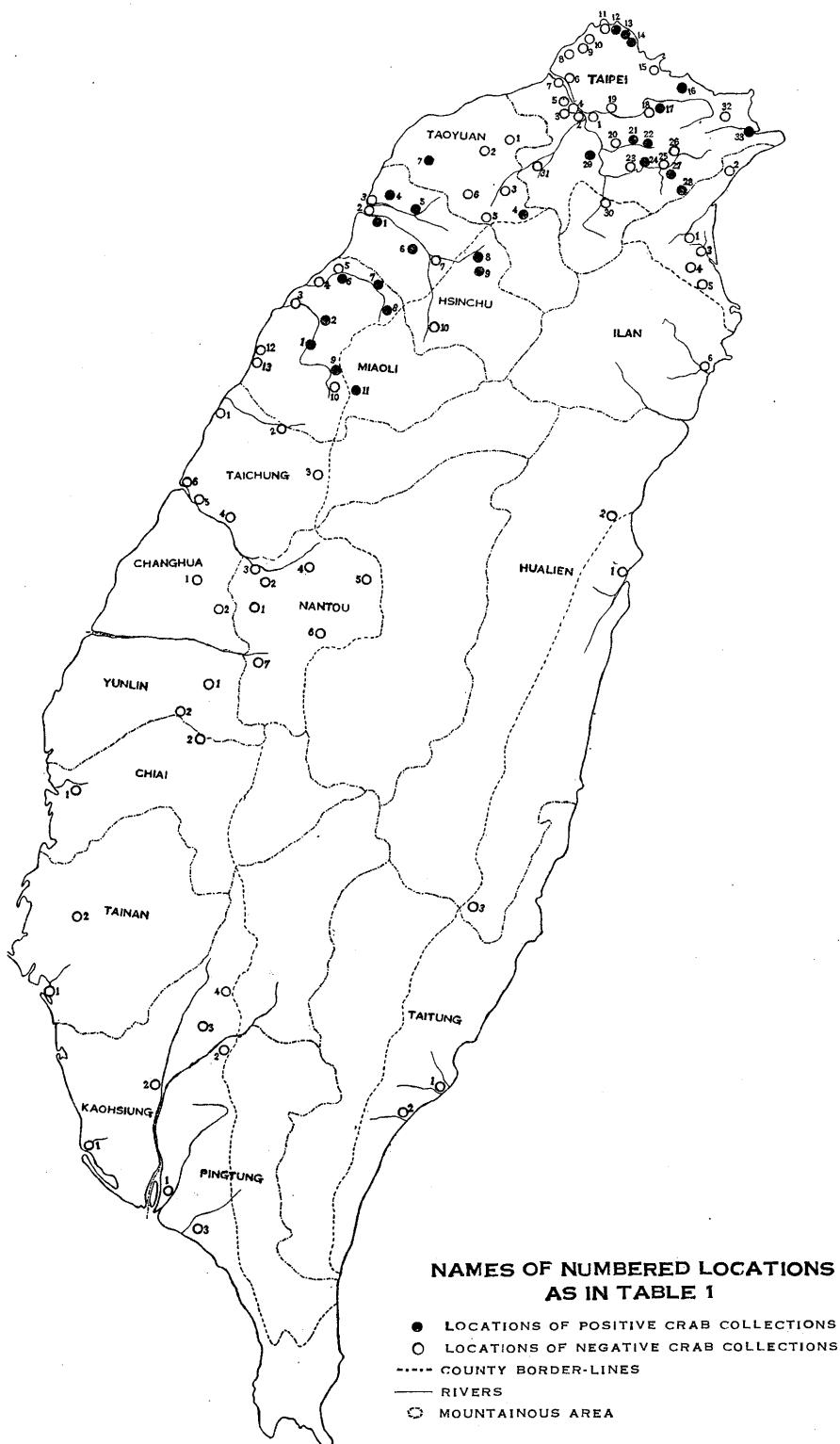


Figure 1. Localities of crab collections in Taiwan (1959-1962 & 1964)

TABLE I
Prevalence of Paragonimus infection in crab hosts in Taiwan

Locality	Species of crab	No. exam.	No. posit. (%)	No. cysts (MPC*)	P. w. or P. i.
Taipei County					
1. Yuan-san (圓山)	<i>S. dehaani</i>	60	—	—	
2. Erh-chung-pu (二重埔)	<i>S. dehaani</i>	27	—	—	
3. Lu-chou (蘆洲)	<i>S. dehaani</i>	65	—	—	
4. Lou-tzu-tsu (樓仔厝)	<i>S. dehaani</i>	67	—	—	
5. Cheng-tzu-liao (成子寮)	<i>S. dehaani</i>	42	—	—	
	<i>E. japonicus</i>	24	—	—	
6. Chu-wei (竹圍)	<i>S. dehaani</i>	156	—	—	
	<i>S. bidens</i>	405	—	—	
	<i>S. plicatum</i>	523	—	—	
	<i>H. tridens tridens</i>	156	—	—	
	<i>H. tridens wuana</i>	80	—	—	
	<i>C. convexus</i>	104	—	—	
7. Pa-li (八里)	<i>S. dehaani</i>	48	—	—	
	<i>S. bidens</i>	25	—	—	
	<i>S. plicatum</i>	18	—	—	
	<i>S. haematocheir</i>	32	—	—	
8. Sin-hua-tien (興化店)	<i>E. japonicus</i>	33	—	—	
9. Hsi-pan (錫板)	<i>E. japonicus</i>	50	—	—	
10. Pa-lien (八連)	<i>E. japonicus</i>	35	—	—	
11. Lao-me (老梅)	<i>S. haematocheir</i>	47	—	—	
12. Shi-men (石門)	<i>S. dehaani</i>	39	—	—	
	<i>S. haematocheir</i>	27	—	—	
	<i>E. japonicus</i>	41	13(31.7)	20(0.49)	P. w.
13. Alipon (阿里磅)	<i>E. japonicus</i>	85	41(48.2)	216(2.54)	P. w.
	<i>Potamon</i> sp.	23	—	—	
14. Alilao (阿里荖)	<i>Potamon</i> sp.	909	252(27.7)	758(1.59)**	P. i.
	<i>P. dehaani</i>	42	—	—	
	<i>S. haematocheir</i>	111	—	—	
	<i>S. impressa</i>	10	—	—	
	<i>V. litterata</i>	6	—	—	
	<i>E. japonicus</i>	144	129(89.6)	3,276(22.8)	P. w.
15. Wan-li (萬里)	<i>E. japonicus</i>	31	—	—	
16. Keelung city (基隆市)	<i>E. japonicus</i>	88	3(3.4)	7(0.08)	P. w.
	<i>Potamon</i> sp.	50	—	—	
17. Pao-chang-keng (保長坑)	<i>E. japonicus</i>	77	2(2.6)	2(0.03)	P. w.
18. Hsi-chih (汐止)	<i>S. dehaani</i>	43	—	—	
19. Nei-hu (內湖)	<i>Potamon</i> sp.	52	—	—	
20. Mu-cha (木柵)	<i>E. japonicus</i>	135	—	—	
21. Shen-keng (深坑)	<i>E. japonicus</i>	163	128(78.5)	1,644(10.1)	P. w.

Locality	Species of crab	No. exam.	No. posit. (%)	No. cysts (MPC*)	P. w. or P. i.
22. Shi-ting (石碇)	<i>P. dehaani</i>	299	16(5.4)	24(0.08)	P. w.
	<i>Potamon</i> sp.	168	3(1.8)	12(0.07)	P. w.
	<i>E. japonicus</i>	50	2(4.0)	2(0.04)	P. w.
	<i>P. dehaani</i>	54	—	—	
23. Fan-shu-liao (蕃薯寮)	<i>P. dehaani</i>	125	—	—	
24. Shi-tsao (石槽)	<i>P. dehaani</i>	26	1(3.8)	1(0.04)	P. w.
25. Ping-lin (坪林)	<i>P. dehaani</i>	58	—	—	
26. Yu-kuang (漁光)	<i>P. dehaani</i>	53	—	—	
27. Tao-tiao-tsui (倒吊子)	<i>P. dehaani</i>	184	16(8.7)	28(0.15)	P. w.
28. San-lin (山林)	<i>P. dehaani</i>	68	2(2.9)	2(0.03)	P. w.
29. An-keng (安坑)	<i>E. japonicus</i>	44	2(4.5)	2(0.05)	P. w.
30. Wu-lai (烏來)	<i>P. dehaani</i>	152	—	—	
31. San-hsia (三峡)	<i>E. japonicus</i>	54	—	—	
32. Wu-tan-keng (武丹坑)	<i>Potamon</i> sp.	51	—	—	
33. Kung-liao (貢寮)	<i>E. japonicus</i>	33	2(6.1)	7(0.21)	P. w.
	<i>S. dehaani</i>	51	—	—	
	<i>S. bidens</i>	65	—	—	
Subtotal	<i>S. dehaani</i>	598	—	—	
	<i>S. bidens</i>	495	—	—	
	<i>S. plicatum</i>	541	—	—	
	<i>S. haematocheir</i>	217	—	—	
	<i>S. impressa</i>	10	—	—	
	<i>H. tridens</i> <i>tridens</i>	156	—	—	
	<i>H. tridens</i> <i>wuana</i>	80	—	—	
	<i>C. convexus</i>	104	—	—	
	<i>E. japonicus</i>	1,087	322(29.6)	5,176(4.78)	P. w.
	<i>P. dehaani</i>	1,061	35(3.3)	55(0.05)	P. w.
	<i>Potamon</i> sp.	1,253	3(0.2)	12(0.01)	P. w.
			252(2.0)	—	P. i.
	<i>V. litterata</i>	6	—	—	
Taoyuan County					
1. Taoyuan (桃園)	<i>E. japonicus</i>	51	—	—	
2. Chung-li (中壢)	<i>E. japonicus</i>	67	—	—	
3. Ta-shi (大溪)	<i>E. japonicus</i>	52	—	—	
4. Chiao-pan-san (角板山)	<i>P. dehaani</i>	22	—	—	
	<i>P. rathbuni</i>	63	2(3.2)	2(0.03)	P. w.
5. Shi-men (石門)	<i>P. dehaani</i>	34	—	—	
6. Lung-tan (龍潭)	<i>P. dehaani</i>	38	—	—	
7. Hsin-wu (新屋)	<i>E. japonicus</i>	76	1(1.3)	1(0.13)	P. w.
Subtotal	<i>E. japonicus</i>	246	1(0.4)	1(0.004)	P. w.
	<i>P. dehaani</i>	94	—	—	
	<i>P. rathbuni</i>	63	2(3.2)	2(0.03)	P. w.

Locality	Species of crab	No. exam.	No. posit. (%)	No. cysts (MPC*)	P. w. or P. i.
Hsinchu County					
1. Hsinchu city (新竹市)	<i>E. japonicus</i>	448	21(4.7)	33(0.07)	P. w.
2. Mouth of Tou-chien River (頭前溪口)	<i>S. dehaani</i>	22	—	—	
3. Mouth of Feng-san River (鳳山溪口)	<i>S. dehaani</i>	58	—	—	
4. San-chi (山崎)	<i>E. japonicus</i>	58	6(10.3)	10(0.17)	P. w.
5. Hsin-pu (新埔)	<i>E. japonicus</i>	54	3(5.6)	4(0.07)	P. w.
6. Chu-tung (竹東)	<i>E. japonicus</i>	64	2(3.1)	3(0.05)	P. w.
	<i>P. dehaani</i>	33	—	—	
7. Heng-san (橫山)	<i>P. dehaani</i>	39	—	—	
	<i>P. rathbuni</i>	53	—	—	
8. Chia-lo village (嘉樂村)	<i>P. rathbuni</i>	123	45(36.6)	106(0.86)	P. w.
9. Chin-ping (錦屏)	<i>P. rathbuni</i>	130	2(1.5)	2(0.02)	P. w.
10. Mao-pu (茅甫)	<i>P. rathbuni</i>	75	—	—	
	<i>P. dehaani</i>	27	—	—	
Subtotal	<i>E. japonicus</i>	624	32(5.1)	50(0.08)	P. w.
	<i>P. dehaani</i>	99	—	—	
	<i>P. rathbuni</i>	381	47(12.3)	108(0.28)	P. w.
	<i>S. dehaani</i>	80	—	—	
Miaoli County					
1. Hao-kang (鶴岡)	<i>E. japonicus</i>	75	21(28 0)	65(0.87)	P. w.
2. Tou-wu (頭屋)	<i>E. japonicus</i>	44	1(2.3)	1(0.02)	P. w.
3. Hou-lung (後龍)	<i>E. japonicus</i>	44	—	—	
	<i>S. dehaani</i>	23	—	—	
	<i>H. tridens tridens</i>	13	—	—	
4. Tan-wen (談文)	<i>E. japonicus</i>	27	—	—	
	<i>S. dehaani</i>	42	—	—	
5. Chu-nan (竹南)	<i>E. japonicus</i>	27	—	—	
6. Tou-fen (頭份)	<i>E. japonicus</i>	35	3(8.6)	5(0.14)	P. w.
7. San-wan (三灣)	<i>E. japonicus</i>	39	2(5.1)	2(0.05)	P. w.
	<i>P. dehaani</i>	74	—	—	
8. Nan-chuang (南庄)	<i>P. rathbuni</i>	54	2(3.7)	2(0.04)	P. w.
	<i>P. dehaani</i>	13	—	—	
	<i>E. japonicus</i>	32	1(3.1)	1(0.03)	P. w.
9. Wen-shui (汶水)	<i>P. rathbuni</i>	67	3(4.5)	3(0.04)	P. w.
10. Ta-hu (大湖)	<i>P. rathbuni</i>	29	—	—	
	<i>P. dehaani</i>	31	—	—	
11. Kao-hsung Pass (高熊崎)	<i>P. rathbuni</i>	116	31(26.7)	119(1.03)	P. w.
12. Tung-hsiao (通霄)	<i>E. japonicus</i>	37	—	—	
	<i>S. dehaani</i>	30	—	—	
	<i>V. litterata</i>	21	—	—	

Locality	Species of crab	No. exam.	No. posit. (%)	No. cysts (MPC*)	P. w. or P. i.
13. Yuan-li (苑裡)	<i>E. japonicus</i>	36	—	—	
	<i>S. dehaani</i>	33	—	—	
Subtotal	<i>E. japonicus</i>	396	28(7.1)	74(0.19)	P. w.
	<i>P. rathbuni</i>	266	36(13.5)	124(0.47)	P. w.
	<i>P. dehaani</i>	118	—	—	
	<i>S. dehaani</i>	128	—	—	
	<i>H. tridens tridens</i>	13	—	—	
	<i>V. litterata</i>	21	—	—	
Taichung County					
1. Ta-an-kang (大安港)	<i>E. japonicus</i>	22	—	—	
	<i>S. dehaani</i>	68	—	—	
	<i>S. plicatum</i>	22	—	—	
	<i>G. depressa</i>	265	—	—	
	<i>H. penicillatus</i>	105	—	—	
2. Ta-an (大安)	<i>E. japonicus</i>	51	—	—	
3. Hsin-po-kang (新伯公)	<i>P. rathbuni</i>	26	—	—	
4. Wu-jih (烏日)	<i>P. dehaani</i>	33	—	—	
5. Ta-tu (大肚)	<i>E. japonicus</i>	50	—	—	
6. Mouth of Ta-tu River (大肚溪口)	<i>H. tridens tridens</i>	47	—	—	
	<i>H. tridens wuana</i>	20	—	—	
	<i>C. convexus</i>	23	—	—	
Changhua County					
1. Yuan-lin (員林)	<i>E. japonicus</i>	28	—	—	
2. She-tou (社頭)	<i>P. formosanus</i>	38	—	—	
Nantou County					
1. Nantou (南投)	<i>P. formosanus</i>	19	—	—	
2. Chung-hsing village (中興新村)	<i>P. formosanus</i>	43	—	—	
	<i>P. rathbuni</i>	20	—	—	
	<i>P. dehaani</i>	24	—	—	
3. Tsao-tun (草屯)	<i>P. formosanus</i>	25	—	—	
4. Ma-lin-keng (馬鄰坑)	<i>P. rathbuni</i>	161	—	—	
5. Pu-li (埔里)	<i>P. dehaani</i>	45	—	—	
6. Shui-she (水社)	<i>P. dehaani</i>	18	—	—	
7. Chu-san (竹山)	<i>P. dehaani</i>	33	—	—	
	<i>P. formosanus</i>	11	—	—	
	<i>P. sinensis</i>	11	—	—	
Yunlin County					
1. Tou-liu (斗六)	<i>P. formosanus</i>	27	—	—	
2. Shih-kuei-hsi (石龜溪)	<i>P. sinensis</i>	18	—	—	

Locality	Species of crab	No. exam.	No. posit. (%)	No. cysts (MPC*)	P. w. or P. i.
Chiai County					
1. Po-tzu (朴子)	<i>H. tridens tridens</i>	19	—	—	
	<i>C. convexus</i>	13	—	—	
2. Mei-san (梅山)	<i>P. sinensis</i>	20	—	—	
Tainan County					
1. An-pin (安平)	<i>H. tridens tridens</i>	23	—	—	
2. Ma-tou (麻豆)	<i>P. sinensis</i>	36	—	—	
Kaohsiung County					
1. Kaohsiung city (高雄市)	<i>S. bidens</i>	24	—	—	
	<i>V. litterata</i>	12	—	—	
2. Ling-kou (檳口)	<i>P. dehaani</i>	25	—	—	
3. Mei-noung (美濃)	<i>P. dehaani</i>	67	—	—	
	<i>P. rathbuni</i>	85	—	—	
4. Liu-kuei (六龜)	<i>P. rathbuni</i>	51	—	—	
	<i>P. dehaani</i>	46	—	—	
Pingtung County					
1. Hsin-yuan (新園)	<i>S. bidens</i>	37	—	—	
	<i>V. litterata</i>	15	—	—	
2. Kao-shu (高樹)	<i>P. dehaani</i>	39	—	—	
3. Chia-tung (佳冬)	<i>E. rectus</i>	36	—	—	
	<i>V. litterata</i>	32	—	—	
Ilan County					
1. Ilan city (宜蘭市)	<i>E. japonicus</i>	40	—	—	
2. Kuei-san (龜山)	<i>E. japonicus</i>	41	—	—	
3. Chuang-wei (壯圍)	<i>E. japonicus</i>	47	—	—	
	<i>S. dehaani</i>	55	—	—	
	<i>V. litterata</i>	51	—	—	
4. Lo-tung (羅東)	<i>E. japonicus</i>	51	—	—	
5. Tung-san (冬山)	<i>E. japonicus</i>	26	—	—	
6. Ta-nan-au (大南澳)	<i>E. rectus</i>	106	—	—	
Hualien County					
1. Hualien city (花蓮市)	<i>E. rectus</i>	31	—	—	
2. Hsiu-lin (秀林)	<i>P. rathbuni</i>	28	—	—	
3. Fu-li (富里)	<i>P. rathbuni</i>	234	—	—	
Taitung County					
1. Taitung (臺東)	<i>E. rectus</i>	56	—	—	
2. Chih-pen (知本)	<i>P. rathbuni</i>	27	—	—	

Locality	Species of crab	No. exam.	No. posit. (%)	No. cysts (MPC*)	P. w. or P. i.
Total					
	<i>E. japonicus</i>	2,709	383(14.1)	5,301(1.96)	P. w.
	<i>E. rectus</i>	229	—	—	
	<i>P. Rathbuni</i>	1,342	85(6.3)	234(0.17)	P. w.
	<i>P. dehaani</i>	1,702	35(2.1)	55(0.03)	P. w.
	<i>P. formosanus</i>	163	—	—	
	<i>Potamon</i> sp.	1,253	3(0.2) 252(2.0)	12(0.01)	P. w. P. i.
	<i>P. sinensis</i>	85	—	—	
	<i>S. dehaani</i>	929	—	—	
	<i>S. bidens</i>	556	—	—	
	<i>S. plicatum</i>	563	—	—	
	<i>S. haematocheir</i>	217	—	—	
	<i>S. impressa</i>	10	—	—	
	<i>H. tridens tridens</i>	258	—	—	
	<i>H. tridens wuana</i>	100	—	—	
	<i>C. convexus</i>	140	—	—	
	<i>V. litterata</i>	137	—	—	
	<i>G. depressa</i>	265	—	—	
	<i>H. penicillatus</i>	105	—	—	

* MPC=An average number of metacercariae per crab examined.

** This figure was calculated from the 476 crabs examined during the period from July 1961 to February 1962.

TABLE II
Comparison of the intensity of Paragonimus westermani infections between Kinugasa's (1943) and the present studies

County	Observer	<i>Eriocheir japonicus</i>			<i>Potamon Rathbuni</i>		
		No. exam.	No. posit.	MPC*	No. exam.	No. posit.	MPC*
Taoyuan	Kinugasa	846	2	0.002	851	896	1.05
	Present study	246	1	0.004	63	2	0.03
Hsinchu	Kinugasa	1,451	115	0.08	1,096	2,353	2.15
	Present study	624	50	0.08	381	108	0.28
Miaoli	Kinugasa	1,831	1,202	0.66	970	2,085	2.15
	Present study	396	74	0.19	266	124	0.47

* MPC=An average number of metacercariae per crab examined.

only in Taipei County. There is little doubt that an extensive survey would find this species of crab infected with *Paragonimus* metacercariae in Hsinchu and Miaoli Counties, particularly in the mountainous area. These two counties are well

known as endemic areas for *P. westermani* and moreover, Nakagawa (7) first incriminated *P. dehaani* as the crab host of *P. westermani* in this locality. An undescribed species of crab, *Potamon* sp., was recorded as the host for *P. westermani* for

the first time (8). In spite of every possible effort the search for *Parathelphusa sinensis*, as a crab host for *P. westermani* reported by Yokogawa (9) at Shen-keng of Taipei County, failed. This crab was collected from places south of central Taiwan where no infected crabs have been found.

The rodent lung fluke, *P. iloktsuenensis*, was recovered from *Potamon* sp., collected from the northern tip of Taiwan (6). It is of interest that *Potamon* sp. acts as the concurrent host for *P. westermani* and *P. iloktsuenensis*. Examinations in 1964 showed that the prevalence of *P. iloktsuenensis* infection has decreased since 1961. Only 8 (6.3%) of 127 crabs examined were parasitized with cysts as compared with 244 (31.2%) of 782 crabs examined during a previous time. This decrease is probably due to the effective rodent control program conducted by the local government and the great number of snail and crab collections made at this limited focus.

Although many brackish water crabs were examined, no *Paragonimus* metacercariae were recovered from them.

Four species of small crab-transmitted flukes besides *Paragonimus* were found in the present study. A new avian intestinal fluke *Macrostomotrema tamsuiensis* was described in two species of the brackish water crabs, *Sesarma bidens* and *S. plicatum*, from the Tamsui River in northern Taiwan (10). This fluke was also found in the crab, *S. bidens*, from the I River of Kaohsiung city. A rodent intestinal fluke *Microphalloides japonicus* was recovered, for the first time in Taiwan, from the brackish water crabs, *Helice tridens tridens*, *H. tridens wuana* and *Chasmagnathus convexus*, collected from the mouth of the Tamsui River (11). An avian intestinal fluke *Gynaecotyla squatarolae* was found, for the first time in Taiwan, in the crab, *Goetice depressa*, collected on the beach of Ta-an-kang in Taichung County. The infection rate was 56.6%. The cysts were found in the green glands of the crab only and varied from 1 to 46 in numbers

per crab, averaging 4.4 per crab. The cysts are round to broad ovoidal in shape, 257.4 to 330.0 μ long by 235.6 to 327.0 μ wide (average: 296.3 \times 284.1 μ). The cyst wall consists of a thin inner membrane (2.3 to 5.6 μ , average 3.6 μ) and a thick outer membrane (4.6 to 16.5 μ , average 8.3 μ). A small liver fluke *Stephanolecithus parvus*, which was described by Yokogawa (12) and Nakagawa (13) in Taiwan, is widely distributed in central and northern parts of the island. The cysts were found for the most part in the liver, muscles and gills of the crabs, *P. rathbuni* and *P. dehaani*. The rates of infection varied from 15.4 to 59.6% according to the species of crab and locality. Mixed infections with *P. westermani* were quite common in *P. rathbuni* in Hsinchu and Miaoli Counties. The cysts of *S. parvus* are 156.8 to 184.8 μ in diameter, averaging 171.9 μ . The cyst wall is composed of two layers, 3.6 to 6.3 μ thick, averaging 5.0 μ .

Acknowledgments The author is grateful to Dr. W. H. Huang, Chairman of the Department of Parasitology, College of Medicine, National Taiwan University, Dr. I. Miyazaki, Dean of the Faculty of Medicine, Kyushu University of Japan, and Dr. Robert E. Kuntz, former Head of the Parasitology Department of the U. S. Naval Medical Research Unit No. 2, Taipei, Taiwan, for their encouragements. Thanks are also due to Dr. S. Miyake, Head of the Department of Zoology, Faculty of Agriculture, Kyushu University of Japan, for identification a part of the crabs.

LITERATURE CITED

1. DIESSING, K. M. 1850. *Systema helminthium*. vol. 1, Vindobonae.
2. KINUGASA, M. 1943. Investigation on incidence of lung fluke disease (*Paragonimus westermani*) in Sintiku Prefecture. V. On its distribution and relation between the fluke and the vector, the fresh water crab. *J. Formosan Med. Assoc.* 42 (Supplement 1): 39-61. (In Japanese with English summary)
3. SAI, K. 1943. On the lung fluke disease (*Paragonimiasis westermani*) in Taichu Prefecture. II. Results of the examination of the cercaria parasitic on the crabs collected

from various rivers in Taichu Prefecture. *J. Formosan Med. Assoc.* **42**: 966-970. (In Japanese with English summary)

4. HUANG, W. H. and J. K. CHIU. 1958. The incidence of *Paragonimus* metacercariae infection in *Eriocheir japonicus* being marketed in Taipei, Taiwan. *J. Formosan Med. Assoc.* **57**: 158-168. (In Chinese with English summary)
5. WATTEN, R. H., R. E. KUNTZ and H. Y. LIU. 1960. Use of purified antigens for detection of *Paragonimus westermani* and *Clonorchis sinensis* in peoples of Hsinchu Hsien, Taiwan (Formosa). *J. Formosan Med. Assoc.* **59**: 364-370.
6. CHIU, J. K. 1962. Two species of *Paragonimus* occurring at Alilao village of Taipei County, Taiwan (Formosa). *Kyushu J. Med. Sci.* **13**: 51-66.
7. NAKAGAWA, K. 1915. Preliminary report on the discovery of the intermediate host of the human lung distomes. *J. Formosan Med. Assoc.* **148**: 121-126. (In Japanese)
8. CHIU, J. K. 1962. Intermediate hosts of *Paragonimus westermani* at Shen-keng District of Taipei County, Taiwan (Formosa). *J. Parasit.* **48**: 423-426.
9. YOKOGAWA, S. and K. MORISHITA. 1931. *Handbook of Human Parasitology*, vol. 1, Tohodo Shoten, Tokyo. p 181. (In Japanese).
10. CHIU, J. K. 1961. *Macrostomotrema tamsuiensis* n. gen., n. sp. (Trematoda: Microphallidae) from river crabs of Taiwan (Formosa). *Proceed. Helminth. Soc. Washington.* **28**: 200-206.
11. CHIU, J. K. 1960. *Microphalloides japonicus* (Osborn, 1919) Yoshida, 1938 (Trematoda: Microphallidae) from river crabs of Taiwan (Formosa). *Chinese Med. J. (Republic of China).* **7**: 103-110.
12. YOKOGAWA, S. 1916. A small crab-transmitted fluke other than *Paragonimus westermani*. *J. Formosan Med. Assoc.* **175**: 298-307. (In Japanese).
13. NAKAGAWA, K. 1917. Adult worm of small type metacercariae found in *Potamon* crabs. *Tokyo Med. J.* **2035**: 1629-1631. (In Japanese).